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Standard Method for Measurement of Nonvolatile Residue on Surfaces

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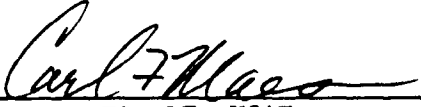
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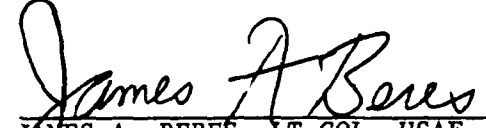
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<p>Contamination analyses are used to determine if materials, components, and subsystems can be expected to meet the performance requirements of a system. Of particular concern is the quantity of molecular contaminants which might be deposited on critical payload surfaces from these sources. This would include all time periods from fabrication, through loading into the vehicle, launching, and during the lifetime of the spacecraft in orbit.</p> <p>A method for determining the mass of nonvolatile residue (NVR) was generated at The Aerospace Corporation by the authors, and the procedure was accepted by the ASTM as Standard E1235, in May 1988. The standard applies to the mass of NVR deposited on 1-sq-ft witness plates exposed in clean rooms, clean work areas, and clean enclosures. This report describes a wipe method for collecting molecular contaminants from any surface and procedures for gravimetric analysis of the NVR so obtained.</p>				
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I. INTRODUCTION

Molecular contamination can result from the outgassing of materials used in and around spacecraft. Choice of spaceworthy materials depends on factors such as performance requirements, payload configuration, mission lifetimes, orbital environment, and costs. The ASTM E595-84 standard method of determining total mass loss (TML) and collected volatile condensable materials (CVCM) (Ref. 1) is widely used to screen candidate materials. Selection of materials strictly by this standard, however, does not ensure that spacecraft cleanliness and performance requirements will be met. Some materials will be exposed to temperatures higher or lower than the 125°C specified in the E595 test. To complicate matters, there is no assurance that batches of materials procured for a project will actually have the same properties as those previously tested. This may be the result of changes in compositions and manufacturing processes or problems. This emphasizes the importance of good quality control to verify the acceptability of materials before use in space systems.

One approach to obtain realistic outgassing data is to test components and subsystems in thermal vacuum chambers under simulated flight environments. Molecular contaminants are collected on cold fingers according to the method described in ASTM E834-81 (Ref. 2). The nonvolatile residue (NVR) is determined gravimetrically and identification of contaminants is made from Fourier transform infrared (FTIR) measurements. Another approach to control all potential sources of molecular contamination is to monitor facilities at launch sites using both active sensors and passive witness plates. Real-time measurements provide an early warning of potential contamination hazards so that corrective actions can be taken before hardware is damaged.

The solvent rinse method described in ASTM Standard E1235-88 (Ref. 3) is an analytical method for determining the mass of NVR deposited on a 1-sq-ft plate in a clean work area or clean enclosure. The wipe method

outlined in this report is for determining the mass of NVR deposited on any surface in any environment. The method covers the determination of the amount of NVR on metal or other surfaces that are nonreactive to the solvents used in the test. The NVR of interest is that which is present on the surface at room temperature (25°C).

II. DESCRIPTION OF WIPE METHOD

The NVR is removed from a known area of a surface using Soxhlet-extracted wipers and a solvent mixture of 75% 1,1,1-trichloroethane (methyl chloroform), and 25% ethyl alcohol (ethanol) with less than 1 ppm of NVR. The NVR is extracted from the wipers with additional solvent which is evaporated to dryness at $25 \pm 5^{\circ}\text{C}$ either in a vacuum oven or in a class 100 unidirectional air flow hood. The mass of the residue minus the mass of a blank, divided by the area wiped, is equal to the mass per unit area of NVR on the surface. The mass of the blank includes the NVR in the cloth and solvent and any NVR picked up during handling and evaporation.

The standard wipe method for determining the mass per unit area of nonvolatile residue on surfaces is presented in Appendix A.

III. DISCUSSION OF METHOD

A. NVR SOLVENT

1. AVAILABILITY

The mixed NVR solvent having less than one part per million (ppm) purity, called out in this procedure, has been somewhat difficult to obtain from ordinary chemical suppliers and sometimes even from Thermo Analytical. In order to prepare the NVR solvent with the purity specified in the test method, it is suggested that individual laboratories purchase either spectro-grade 1,1,1-trichloroethane (TCA) and ethanol (EtOH) or high purity semiconductor grade, both types having been purified to a much higher level than ordinary reagent grade. Some of these solvents have been found to be pure enough to be used in the method directly from the container. A list of suppliers of high purity solvents for the electronics industry is given in Appendix B.

Before mixing the solvents (75 TCA: 25 EtOH) together, the NVR of each one should be certified according to the procedure described in ASTM Standard E1235-88, Section 10. If the NVR exceeds 130 ± 10 micrograms, the contaminated solvent should be distilled and the NVR redetermined. Impurities below one ppm may be identified by analyzing solvent vapors in a gas chromatograph (GC) equipped with a hydrogen flame ionization detector. Mass spectrometers (MS) have also been used to obtain information on the identity of solvent constituents. A typical MS spectrum for the NVR solvent used in the method described in Appendix A is shown in Fig. 1.

2. LIMITATIONS

Purity of the NVR solvent should be verified at about three month intervals if quantities are stored in partially filled containers. Halogenated hydrocarbons will decompose by hydrolysis if water is present and will form mineral acids such as acetic and hydrochloric. These acids

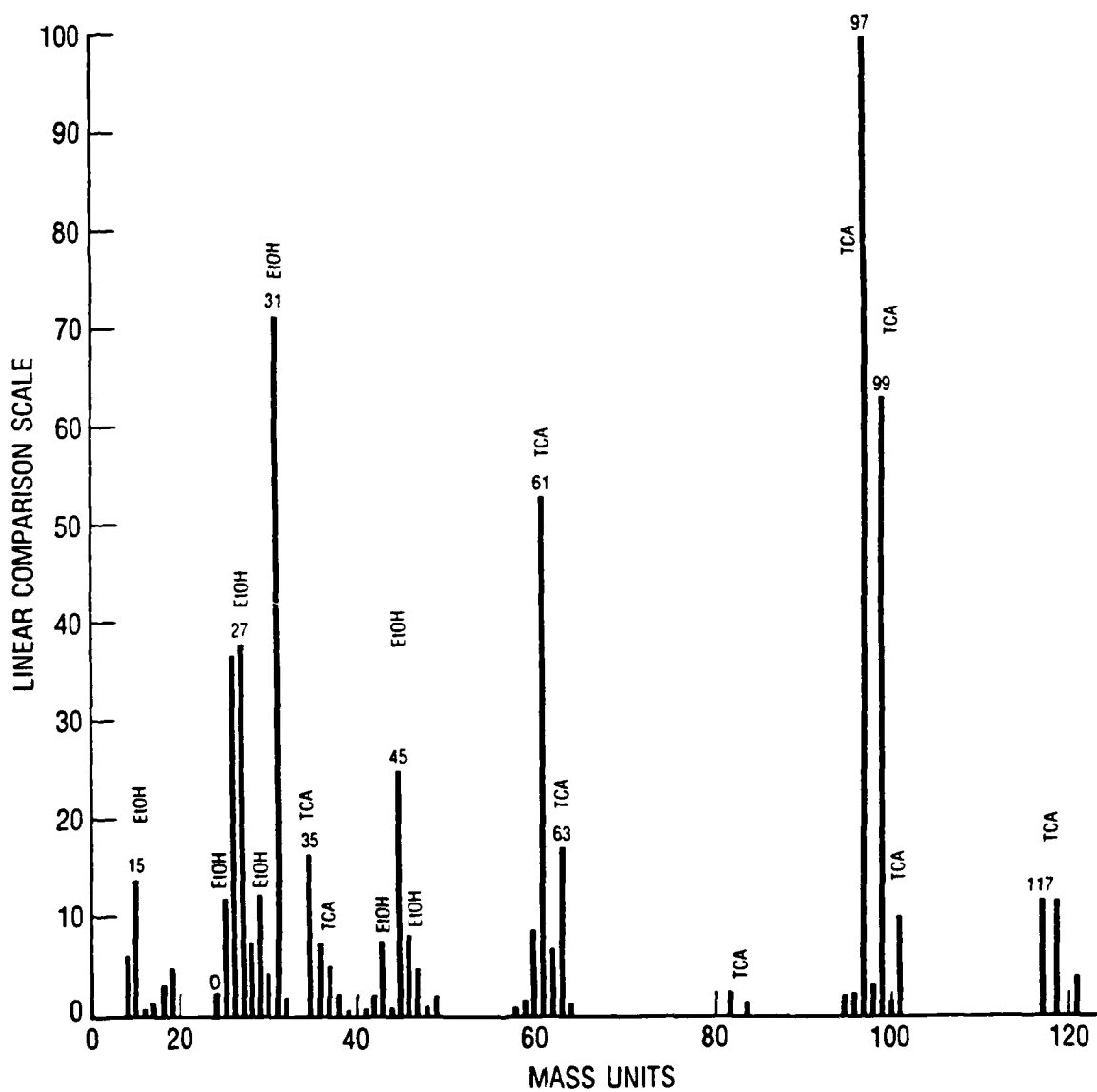


Fig. 1. Mass Spectrum Obtained From NVR Solvent (1,1,1, TCA + EtOH)
(NVR less than 5 ppm)

can initiate corrosion of aluminum surfaces because they destroy the protective surface oxide film naturally present that provides resistance to corrosion.

Aluminum is most resistant to hydrocarbons halogenated with fluorine, followed in order of decreasing resistance to those with chlorine, bromine, and iodine. The behavior of aluminum in a mixture of halogenated hydrocarbons, or mixtures of these hydrocarbons with other organic compounds, cannot be predicted from its behavior with each of the components. For example, mixtures of carbon tetrachloride and methyl alcohol produce rapid corrosion of aluminum at ambient temperatures, even though the components alone do not. Magnesium and certain magnesium alloys are similarly affected.

3. TOXICITY AND HAZARDS

Organic solvents are derived from hydrocarbons and are used to dissolve other organic materials. The halogenated aliphatic hydrocarbon group includes carbon tetrachloride, trichloroethane, dichloromethane, and trifluorotrchloroethane (Freon). All organic solvents are toxic at some level of exposure and can seriously damage the health of workers who use them without proper precautions and adequate controls. Carbon tetrachloride is highly toxic and, through penetration of the skin and inhalation of vapors, will attack the kidney and the liver. The others are moderately toxic and will defat the skin on contact, producing dermatitis and irritation. Excessive exposure to vapors will produce loss of coordination, headache, and even unconsciousness (Ref. 4). The alcohol group of organic solvents includes methanol, ethanol, and propanol; their degree of toxicity varies widely, affecting the central nervous system, vision, and the liver. Material Safety Data Sheets for the solvents discussed in this report are included in Appendix C.

B. ALTERNATIVE SOLVENTS

1. METHYLENE CHLORIDE

High-purity liquid chromatography (HPLC) grade methylene chloride (dichloromethane, DCM) instead of the TCA:EtOH solvent mixture

described in this report has been used or considered as an NVR solvent. DCM certainly has been shown to be an excellent solvent for many types of contaminants, including cellulose esters, fats, oils, resins, and rubber. Extensive studies of the possible carcinogenicity in humans of the highly volatile DCM (Refs. 5-7), however, shed some real doubt as to the safety of using the solvent either in field sampling or in confined, nonvented places. Methylene chloride has been shown to induce increased numbers of benign and malignant neoplasms in rats and mice and thus meets the criteria provided in the OSHA Cancer Policy for classification as a potential occupational carcinogenic substance. The National Institute for Occupational Safety and Health (NIOSH) recommends that methylene chloride be considered a potential human carcinogen in the workplace.

Recently it has been recognized that DCM and some other dichloromethanes are metabolized to carbon monoxide. The principal problem from use is the "drunkenness" that may cause inept operation, which may result in injury to the employee or others around him. The symptoms of excessive exposure may be dizziness, nausea, tingling or numbness of extremities, a sense of fullness in the head, stupor, and lethargy. Exposure to very high concentrations may lead to rapid unconsciousness and death. By controlling DCM exposures to the lowest feasible limit, workers can ensure that the concentration of carboxyhemoglobin in the blood does not exceed acceptable levels as described in the 1976 NIOSH criteria document (Ref. 8). The ASTM E1235-88 standard specifies the use of an exhausting clean-air bench when handling DCM because of potential toxicity problems.

2. CARBON TETRACHLORIDE

The solvent carbon tetrachloride (tetrachloromethane) is still used in a few laboratories for the NVR procedure. This practice should be discouraged because of extreme hazards. Carbon tetrachloride is a suspected carcinogen in humans. Exposure to high concentrations of the solvent results in depression of the central nervous system (CNS). If the concentration is not high enough to lead to rapid loss of consciousness,

other indications of CNS effects such as dizziness, vertigo, headache, depression, mental confusion, and incoordination are observed. Many individuals also show gastrointestinal responses such as nausea, vomiting, abdominal pain, and diarrhea. Functional and destructive injury of the liver and kidney may occur from a single acute exposure, but it is more likely to occur from repeated exposures. In cases of long-term chronic exposure to low solvent concentrations, kidney and liver injuries dominate the picture. At threshold concentrations, injury is chiefly to the liver and appears as a malfunction and/or enlargement of the organ.

C. CLEAN ROOM WIPERS

1. AVAILABILITY

The NVR method in this report describes clean room wipers of cotton or monofilament polyester that are Soxhlet-extracted in the NVR solvent to a cleanliness level of less than 5 ppm NVR. All commercial clean room wipers contain a wide variety and various quantities of NVR contaminants. These include surfactants, sizing compounds, waxes, oils, adhesives, electrostatic agents, and greases. If they are used directly from the package with a particular solvent, the contaminants are dissolved or dispersed and are transferred to the hardware surface being cleaned. It becomes obvious that an item can be made no cleaner than the material used for cleaning (Ref. 9). The suggested approach is to buy wipers having the lowest NVR levels available and to perform further extraction in the NVR solvent.

The most commonly used method of removing NVR from wipers is by cycling them in hot solvent in a Soxhlet extraction apparatus. This can be a slow process in a small laboratory-size extractor. Volume extractions are, however, available commercially from laundries operated in accordance with USAF T.O. 00-25-203 (Ref. 10), and cycles and times can be repeated in order to attain the specified NVR value of less than 5 ppm. The NVR level and identification of any residual contaminants should be verified prior to use by gravimetric, GC/MS, and/or IR analytical methods.

Another method for reducing NVR in small batches of wipers has been reported by Lockheed Missiles and Space Co., Inc. researchers (Ref. 11). Wipers are soaked in 500 ml of NVR solvent for a period of no less than 6 hr under constant agitation on a shaker table. The solution taken from each wiper is then filtered and condensed in a rotary vacuum evaporator until only a small volume remains. This solution is then transferred to a weighing dish where it is evaporated to dryness in an oven at 110°C according to ASTM Procedure F331-72 (Ref. 12). The residue remaining is weighed to determine the mass of NVR extracted. The NVR determined by this procedure, using an evaporation temperature of 110°C, will probably be lower than the NVR obtained using evaporation temperatures in the range of 25°C to 35°C. The value, therefore, will not be representative of NVR that could remain on spacecraft surfaces.

2. EFFECTIVENESS

Cellulose or paper products as a group have fairly low amounts of extractable organic residues. Unfortunately, they are not ideal products for use in clean rooms because of the excessive amount of particles they deposit on surfaces when used. Polyesters are the next lowest in extractable organic residues. Cottons follow polyesters, with a moderate amount of NVR being extracted from the wipers. Synthetics like nylons, polyamides, polyurethanes, and polypropylenes contain large amounts of extractable materials, much of which result from dissolution of the wiper material in the organic solvent.

Cotton fabrics, without dispute, are the best performers in absorbency tests, but cotton wipers leave more particles on the wiped surface than polyester wipers. If the NVR study is being conducted on critical hardware, then this consideration would be the determining factor in choosing the appropriate clean wiper to clean the surfaces.

D. NVR DETERMINATION

Values of NVR obtained by different laboratories may not always agree, even though surfaces sampled are identically contaminated. The following are several sources of error which can influence the determination of NVR.

1. OVEN TEMPERATURE

The drying oven must be calibrated accurately and should be set at $25 \pm 5^{\circ}\text{C}$. If the temperature is too high, the NVR value will be incorrect because low molecular weight residue will volatilize at the higher temperature, leaving less nonvolatile residue than actually existed on the wiper from the contaminated surface.

2. LABORATORY ENVIRONMENT

The evaporating dish and residue must be allowed to equilibrate to the same room temperature and relative humidity of the microbalance on which the dish is to be weighed. The relative humidity should not vary by more than $\pm 5\%$ and the temperature by not more than $\pm 1^{\circ}\text{C}$ during the weighings. If dishes are reweighed after 15 minutes and the NVR is within $\pm 10 \mu\text{g}$, then evaporation and equilibration are complete. It is important to ensure that laboratory environment (temperature, relative humidity, and air cleanliness) be monitored on a periodic basis.

3. MICROBALANCE

All laboratory equipment must be maintained and well calibrated in order to obtain accurate NVR determinations. The microbalance for weighing NVR should have a precision of $\pm 10 \mu\text{g}$.

IV. SUMMARY

A wipe method for measuring the nonvolatile residue remaining on any surface as a result of outgassing of materials has been outlined in Appendix A. The method incorporates two alternative evaporation procedures. In Procedure A the solvent is evaporated in a vacuum oven, while in Procedure B the solvent is allowed to evaporate in a class 100 unidirectional air flow hood. All other aspects of the method are the same, and no quantitative differences have been observed between the NVR mass determinations. Evaporation Procedure B is generally the choice if large numbers of samples must be processed in a timely manner.

This method is useful for determining molecular surface contamination when witness plates and stationary monitoring instruments cannot be installed at a facility because of space or time limitations, or when payload transportation activities are occurring. The wipe method is particularly useful for monitoring contaminants over large areas such as the Titan IV Payload Fairing, Orbiter Payload Bay, or other massive hardware and also can be used to advantage in places which are otherwise inaccessible.

REFERENCES

1. ASTM E595-84, "Standard Test Method for Total Mass Loss and Collected Volatile Condensable Materials from Outgassing in a Vacuum Environment," Annual Book of ASTM Standards, Vol. 15.03.
2. ASTM E834-81, "Practice for Determination of Vacuum Chamber Gaseous Environment Using a Cold Finger," Annual Book of ASTM Standards, Vol. 15.03.
3. ASTM E1235-88, "Standard Test Method for Gravimetric Determination of Non-Volatile Residue in Environmentally Controlled Areas (for Spacecraft)," Annual Book of ASTM Standards, Vol. 15.03.
4. Patty's Industrial Hygiene and Toxicology, 3d Rev. Edition, Vol. 28, Toxicology, Chapter 48, G. D. and F. E. Clayton, Eds., John Wiley and Sons, N.Y., 1981.
5. EPA/600/8-82/004F, "Health Assessment Document for Dichloromethane (Methylene Chloride)," Final Report, February 1985.
6. EPA/600/8-82/004FF, "Addendum to the Health Assessment Document for Dichloromethane--Updated Carcinogenicity Assessment," Final Report, September 1985.
7. NIOSH, "Current Intelligence Bulletin 46 on Methylene Chloride," 18 April 1986.
8. "Criteria for a Recommended Standard....Occupation Exposure to Methylene Chloride." Cincinnati: U.S. Department of Health, Education, and Welfare, Public Health Service, Center for Disease Control, DHEW (NIOSH) Publication No. 76-138.
9. "Low Extractable Wipers for Cleaning Space Flight Hardware," Veronica Tijerina and Frederick Gross, NASA, Goddard Space Flight Center, NASA CP-2446, 1986.
10. Air Force T.O. 00-25-203, Change II, Contamination Control of Aerospace Facilities, U.S. Air Force (Appendix D).
11. "Cleanroom Wipers: A Comparative Study," Wendy Hovatter and E. Arne Hendrickson, Microcontamination Magazine, December 1984.
12. ASTM F331-72 (1977), Standard Test Method for Non-Volatile Residue of Halogenated Solvent Extract from Aerospace Components (Using Rotary Flash Evaporator), Vol. 15.03.

APPENDIX A. STANDARD WIPE METHOD FOR MEASUREMENT
OF NVR ON SURFACES

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FIGURES

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A.1 SCOPE

1.1 This test method covers the determination of nonvolatile residue (NVR) deposited on surfaces in environmentally controlled areas used for the assembly, testing, and processing of spacecraft.

1.2 The NVR of interest is that which is present on a surface at room temperature (25°C).

1.3 This method may involve hazardous materials, operations, and equipment. This standard does not purport to address all the safety problems associated with its use. It is the responsibility of the user to establish appropriate safety and health practices and to determine the applicability of regulatory limitations prior to use.

1.4 The values stated in SI units are to be regarded as the standard.

A.2 APPLICABLE DOCUMENTS

- | | | |
|-----|--|---|
| 2.1 | T.O. 00-25-203
Change II
21 March 1985 | Contamination Control of Aerospace
Facilities, U.S. Air Force |
| 2.2 | FED-STD-209D
15 June 1988 | Clean Room and Work Station Requirements,
Controlled Environment |
| 2.3 | MIL-F-51068F
5 April 1988 | Filters, Particulate (High Efficiency,
Fire Resistant) |
| 2.4 | ASTM E1235-88
25 March 1988 | Standard Test Method for Gravimetric
Determination of Nonvolatile Residue
(NVR) in Environmentally Controlled
Areas for Spacecraft |
| 2.5 | MIL-C-81302D
16 April 1985 | Cleaning, Compound, Solvent,
Trichlorotrifluoroethane |
| 2.6 | MIL-STD-1246B
4 September 1987 | Product Cleanliness
Levels and Contamination
Control Program |

A.3 DEFINITIONS

- 3.1 contaminant--unwanted molecular and particulate matter that could affect or degrade the performance of the components upon which they reside.
- 3.2 contamination control--the planning, organizing, and implementation of all activities needed to determine, achieve, and maintain a required cleanliness level.
- 3.3 environmentally controlled areas--clean rooms, clean facilities, controlled work areas, and other enclosures that are designed to protect hardware from contamination.
- 3.3.1 discussion--cleanliness is achieved by controlling air purity, temperature, humidity, materials, garments, and personnel activities. Guidelines for controlled areas can be found in Table 3-1 of Air Force T.O. 00-25-203.
- 3.4 molecular contaminant - nonparticulate contaminant-- the molecular contaminant may be in a gaseous, liquid, or solid state. It may be uniformly or nonuniformly distributed, or be in the form of droplets. Molecular contaminants account for most of the NVR.
- 3.5 NVR (nonvolatile residue)--quantity of residual molecular and particulate matter remaining, following the filtration of a solvent containing contaminants and evaporation of the solvent at a specified temperature.

A.4 APPARATUS

The letter(s) following 4.1-4.8 indicate the method for which the specific item of apparatus is applicable. (A) applies to the wipe method with the vacuum evaporation procedure, and (B) applies to the wipe method with the air evaporation procedure.

4.1(A) Analytical microbalance, with 20-g capacity, 10- μ g readability, and ± 10 - μ g precision.⁽¹⁾

4.2(B) Balance, with 160-g capacity, 0.1-mg readability, and ± 0.05 -mg precision.

4.3(AB) Vacuum filtration system, 25-mm diameter, consisting of a membrane filter funnel, Fisher Filtrator assembly⁽²⁾ and vacuum pump that will provide a pressure of 250 Torr (a vacuum of 500 mm Hg). See Fig. A-1.

4.4(A) Vacuum evaporation system, consisting of a vacuum oven, a two-stage vacuum pump, and vacuum gauge. The vacuum oven should be controllable to $25 \pm 5^\circ\text{C}$. The system, shown in Fig. A-2, is exhausted through a series of two low-temperature traps to collect the solvent vapors and prevent damage to the vacuum pump. The solvent traps are cooled using an isopropanol/dry ice bath. The oven shall not produce molecular and particulate contaminants and should not be used for other operations that could contaminate samples.

4.5(AB) Desiccator, 200-mm I.D. with indicating calcium sulfate desiccant.

4.6(AB) Ultrasonic bath.

⁽¹⁾ Sartorius Model 2405 microbalance, Sartorius Model 2434 Semimicro, or equivalent.

⁽²⁾ Fisher filter funnel P/N 09-750 and filtrator assembly P/N 09-788 have been found to be satisfactory. Other suitable filtration apparatus may be used.

4.7(AB) HEPA filtered, class 100, unidirectional air flow, clean work station. Guidelines can be found in T.O. 00-25-203.

4.8(AB) HEPA filtered, class 100, unidirectional air flow, exhausting work station, with 100% exhaust, for handling solvents.

4.8.1 All HEPA filters shall be constructed of low outgassing, corrosion resistant, and fire-resistant materials. MIL-F-51068F, Types IIA and IID, should be considered. The filters shall not be tested with DOP (dioctylphthalate) or other liquid aerosols. Ambient air and solid aerosol test methods are acceptable alternatives to the DOP test.

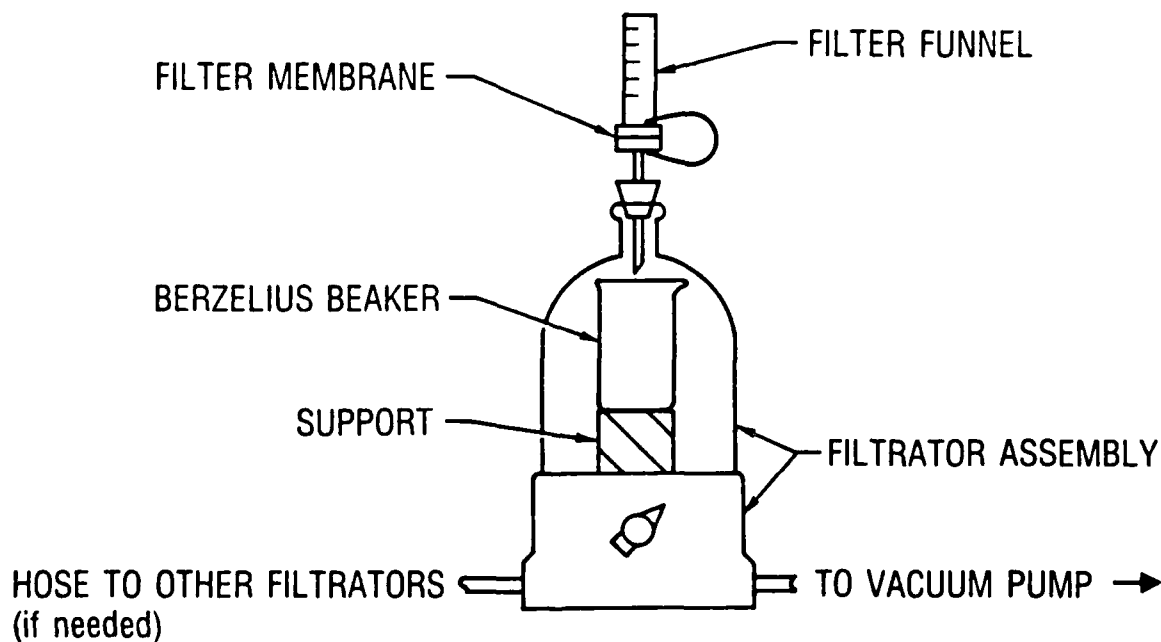


Fig. A-1. Vacuum Filtration System for NVR Extraction From Sample

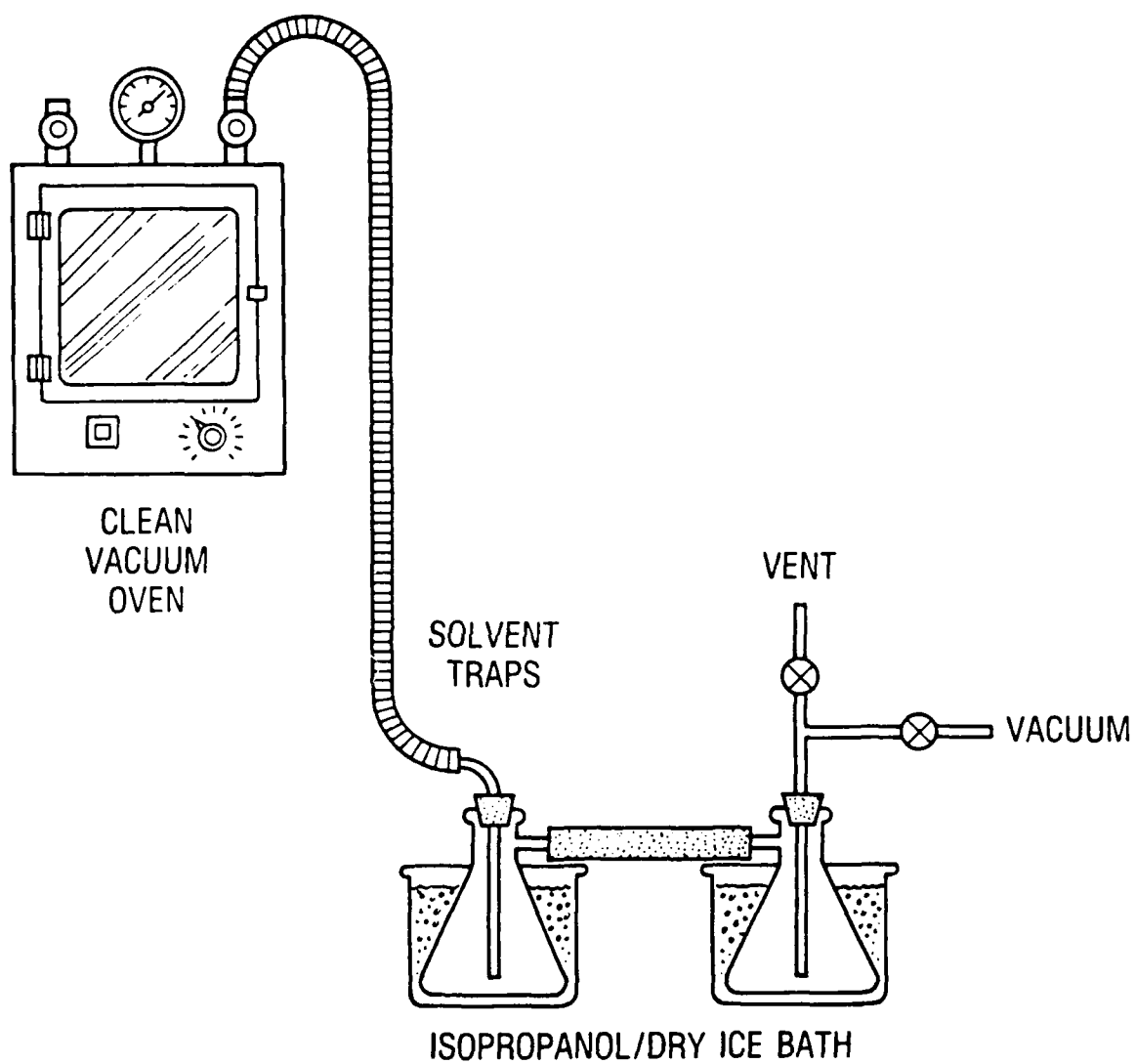


Fig. A-2. Vacuum System for Solvent Evaporation

A.5 REAGENTS AND MATERIALS

The letter(s) following 5.1-5.17 indicate the method for which the specific reagent or material is used. (A) applies to the wipe method with the vacuum evaporation procedure, and (B) applies to the wipe method with the air evaporation procedure.

5.1(AB) NVR solvent composed of 75% 1,1,1-trichloroethane, 25% ethanol, <1 ppm NVR (nominal). Test per ASTM E1235, Section 10.

5.2(AB) Cotton or monofilament polyester cloths, Soxhlet extracted in the 75-25 solvent; these are approximately 150 mm x 200 mm (6 in. x 8 in.) in size and are folded twice. They contain less than 5 ppm NVR.⁽³⁾

5.3(AB) Curved forceps (sponge forceps).

5.4(AB) Teflon coated tweezers.

5.5(AB) NVR solvent containers.

5.6(AB) Container to catch excess NVR solvent during wiping operation.

5.7(AB) Gloves.

5.8(AB) 1,1,1-trichloroethane, reagent grade.

5.9(AB) Methyl alcohol absolute, reagent grade.

5.10(AB) Acetone, reagent grade.

5.11(AB) Sample containers, 100-ml (4-oz) wide-mouth Teflon bottles with Teflon caps.

5.12(AB) Low form beakers, 20 ml.

5.13(AB) Berzelius beakers, 250 ml.

⁽³⁾Optic-Cloth from the Texwipe Co., Hillsdale, NJ, and Soxhlet extracted by Thermo Analytical, Monrovia, CA, has been found to be acceptable. Suitable monofilament polyester cloths are being investigated.

5.14(B) Aluminum foil⁽⁴⁾ dishes, 50 ml.

5.15(B) 0.2- μ m filters, 25-mm diameter that will not be affected by the NVR solvent.⁽⁵⁾

5.16(AB) Trichlorotrifluoroethane, MIL-C-81302D, Type II (Freon type TF), reagent grade.

5.17(AB) Safety regulations for all the solvents used in the wipe method are presented in Appendix B.

⁽⁴⁾Fed Spec Food Service Guide aluminum, oil free, Federal Stock No. 8135-00-724-0551 has been found to be satisfactory.

⁽⁵⁾Nuclepore PTFE Filinert filter, P/N 130606, and Millipore Fluoropore filter, 0.2- μ m, P/N FGLP02500, have been found to be satisfactory. Other equivalent solvent resistant filters may be used. Larger diameter filters to fit larger diameter filtration units may be used.

A.6 CLEANING OF EQUIPMENT

6.1 Cleaning of the glassware and tools is accomplished by washing twice with a strong liquid detergent in water, rinsing with tap water and then deionized water. The object is then rinsed with acetone, next with methanol, and finally with fresh trichlorotrifluoroethane solvent.

6.2 The 20-ml low-form beakers and the aluminum dishes are further dried in a 105°C oven for 30 min and allowed to cool in a desiccator. After cooling, low form beakers are weighed to the nearest μg . The platinum or aluminum dishes are weighed to the nearest 0.1 mg. The tared equipment is then stored in a desiccator. (Use forceps in handling these beakers to avoid contamination.)

6.3 Guidelines for cleaning methods and materials can be found in MIL-STD-1246B.

A.7 SURFACE SAMPLING

7.1 Using two cleaned tweezers, remove a Soxhlet-extracted cloth from its container and roll the cloth to form a wiping bundle approximately 20 mm (3/4 in.) in diameter and 40 mm (1-1/2 in.) long.

7.2 Grasp the bundle with cleaned forceps and moisten with a small quantity of NVR solvent.⁽⁶⁾ Hold the cloth over a container to catch excess solvent. Let excess solvent in the cloth drain off before wiping.

7.3 Select a test area of the surface approximately 0.1 m² (1 ft²) in extent and swab thoroughly. Avoid any contact with sealant or other organic/polymeric materials that are used in the fabrication of the component unless specific authorization has been given. Also avoid contacting the surface with the gloves being worn to protect the hands.

7.4 Place the used swab in a precleaned Teflon sample container and perform a second cleaning of the same area, also placing that used swab in the same sample container. Label the container with the sample identifying number.

7.5 The actual area wiped shall be recorded for each sample.

7.6 Repeat 7.1 and 7.2 with two swabs.

7.7 Skip steps 7.3 and 7.4. Place both unused swabs in a precleaned Teflon sample container. Label the container as the blank or control sample.

⁽⁶⁾The Soxhlet extracted cloth may be premoistened with the NVR solvent and sealed in a solvent compatible container (one that will not add NVR to the solvent). Use two cloths per sample container, then proceed to 7.3.

A.8 SAMPLE EXTRACTION AND SOLVENT EVAPORATION

8.1 SAMPLE EXTRACTION AND EVAPORATION

8.1.1 Extraction of the sample (per Section A.7) consisting of two used cloths, is initiated by transferring the cloths from the sample container to a cleaned 250-ml beaker.

8.1.2 The cloths are soaked with 75 ml of the NVR solvent and ultrasonically agitated for 4 min.

8.1.3 The solvent is poured into the filter funnel fitted with the 0.2- μ m filter membrane and vacuum filtered into a 250-ml Berzelius beaker.

8.1.4 A second 75-ml quantity of NVR solvent is added to the sample cloths and ultrasonically agitated for 4 min. This is also vacuum filtered into the second beaker described in 8.1.3.

8.1.5 A fixed volume of solvent shall be used for each sample.

8.1.6 The filter membrane shall be changed for filtration of solvent from each pair of cloths, and used filter membranes shall be retained and labeled for future analysis.

8.2 EVAPORATION OF SOLVENT - PROCEDURE A

8.2.1 This procedure describes evaporation of the NVR solvent in a vacuum oven.

8.2.2 The beaker of filter solvent containing the NVR is placed in the vacuum oven evaporator, the vacuum pump is turned on, and the pressure decreased to about 3×10^4 Pa (250 torr) (vacuum increased to about 500 mm of mercury).

8.2.3 The temperature of the vacuum oven is set at $25 \pm 5^\circ\text{C}$. If no bumping or boiling occurs, the pressure may gradually be decreased to 7×10^3 Pa (50 torr), which is the typical ultimate of a mechanical pumping system.

8.2.4 The solvent is allowed to evaporate until about 10 ml remains. The vacuum is released and the 10 ml of solvent is transferred

quantitatively to a cleaned, dried, and weighed 20-ml beaker. The transfer may be aided by rinsing the 250-ml beaker with small amounts of the NVR solvent; this should be added to the 20-ml beaker. The volume of solvent added at this time should be the same for each sample. The 20-ml beaker must be handled with tongs to avoid the introduction of any unknown mass to the beaker.

8.2.5 The beaker is returned to the vacuum evaporation system. Evaporation is continued for 15 min past the time when no visible solvent remains in the beaker.

8.2.6 The beaker is then transferred to a desiccator until it is weighed.

8.3 EVAPORATION OF SOLVENT - PROCEDURE B

8.3.1 This procedure describes evaporation of the NVR solvent in air, in a class 100 unidirectional air flow hood.

8.3.2 A small amount of filtrate from the 250-ml beaker is poured into the preweighed metal dish.

8.3.3 The metal dish and the 250-ml beaker, with the remaining filtrate, are placed in the hood. The metal dishes shall be handled in such a way as to preclude contamination. The remaining filtrate in the 250-ml beaker is poured into the metal dish as the solvent in the dish evaporates. Ultimately, all the solvent from the beaker is transferred to the metal dish.

8.3.4 After the metal dish is visibly dry, it is placed in the vacuum desiccator for 15 min prior to weighing. The metal dish and sample are allowed to equilibrate to room conditions of temperature and relative humidity.

8.4 BLANK CORRECTION

8.4.1 The blank reference sample (see 7.7) shall be extracted as per 8.1. Evaporation of the solvent shall follow either Procedure A (8.2) or Procedure B (8.3), whichever coincides with the evaporation procedure employed for the NVR sample.

A.9 CALCULATION OF NVR

The following describes the calculations used in the determination of NVR per unit area:

$$\text{Sample mass (mg)} = \text{Final mass (mg)}^* - \text{Empty container mass (mg)}^{**}$$

$$\text{Blank mass (mg)} = \text{Final mass (mg)}^{***} - \text{Empty container mass (mg)}^{**}$$

$$\text{NVR (mg/0.1 m}^2 \text{ or (mg/ft}^2\text{))} = \frac{\text{Sample mass (mg)} - \text{Blank mass (mg)}}{10^{-3} \times \text{Sampling area (cm}^2\text{)}}$$

*Per 8.2.6.

**Per 6.2.

***Per 8.4.

A.10 SURFACE NVR TEST SHEET

DATE _____

SAMPLE NO. _____

PROGRAM _____

ARTICLE SAMPLED _____

SITE _____

AREA SAMPLE

LOCATION _____

DIMENSIONS _____

1. AREA _____ cm^2 _____

SAMPLE COLLECTED BY _____

COMMENTS _____

LAB DATA DATE _____

2. TOTAL VOLUME OF SOLVENT _____ cm^3 _____

3. FINAL MASS SAMPLE CONTAINER + NVR _____ mg _____

4. INITIAL MASS SAMPLE CONTAINER _____ mg _____

5. NVR MASS UNCORRECTED _____ mg _____

6. FINAL MASS BLANK CONTAINER + NVR _____ mg _____

7. INITIAL MASS BLANK CONTAINER _____ mg _____

8. BLANK MASS _____ mg _____

9.
$$\text{NVR} = \frac{[(5) - (8)]}{10^3 \times (1)}$$
 _____ $\text{mg}/0.1 \text{ m}^2$ _____

ANALYST _____

COMMENTS _____

APPENDIX B. SUPPLIERS OF HIGH PURITY SOLVENTS FOR
THE ELECTRONICS INDUSTRY

Alfa Products/Morton Thiokol
Allied Corporation
Alpha Metals, Inc.
American Burdick & Jackson, Subsidiary of American Hospital Supply Corp.
American Scientific Products, Div. of American Hospital Supply Corp.
Apache Chemicals Inc., Div. of Hunt Chemical Corp.
Ashland Chemical Co., Electronic & Laboratory Products Div.
Atomergic Chemetals Corp.
B.D.H. Limited, Industrial Chemicals Group
J.T. Baker, Inc.
BASF Wyandotte Corporation, Intermediate Chemicals
Brewer Science, Inc.
ChemTech Industries, Inc., Microelectronic Chemicals Division
Cobehn, Inc.
Columbus Chemical Industries Inc.
Corco Chemical Corp.
Dow Chemical USA, Electronics Business Unit
Dynaloy Incorporated
EKC Technology, Inc., Burmar Chemical Division, Micropel & Mycosil
Subsidiaries
EM Industries, Inc., Advanced Chemicals Div.
ESPI, Electronic Space Products International
Filtronics
GAF Chemicals Corporation
GFS Chemicals
J.E. Halma Co., Inc.
HMC-HUB Material Company
Image Technology Corporation
Inland Specialty Chemical Corporation, a Subsidiary of Great Lakes Chemical Corp.
Laporte Industries Limited
M&T Chemicals Inc.
Mallinckrodt, Inc., Science Products Division
McKesson Chemical Company, McKesson Corp.
E. Merck, Industrial Chemicals Division
Micro-Image Technology Limited
Miller-Stephenson Chemical Co., Inc.
Morton Thiokol/Alfa Products
Olin Hunt Specialty Products Inc., Subsidiary of Olin Corporation
J.S. Schumacher Company
Solkatronic Chemicals Inc.
Solutions Plus, Inc.
Tech Spray
Van Waters & Rogers, Univar
VWR Scientific
Wacker-Chemie GmbH
Wako Chemicals USA, Inc.

APPENDIX C. SOLVENT SAFETY DATA SHEETS

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361, Rev. B -- Ethyl Alcohol ($EtOH$, C_2H_6O).....	51
G354, Rev. C -- Methyl Alcohol ($MeOH$, CH_3OH).....	53
310, Rev. D -- Methylene Chloride (CH_2Cl_2).....	55
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SECTION 6. HEALTH HAZARD INFORMATION		TLV 750 ppm (see Section 2)
<p>Acetone is a low toxicity solvent. Inhalation of small quantities of acetone vapors over long periods causes irritation of the respiratory tract, coughing and headache. Inhalation of acetone vapors in high concentrations produces dryness of the mouth and throat, dizziness, nausea, incoordinated movements, loss of coordinated speech, drowsiness, and in extreme cases, coma. Prolonged or repeated skin contact has a defatting effect causing drying, irritation, and mild dermatitis. Under normal circumstances, the amount of acetone that is absorbed through the skin is quite small. Although systemic injury is unlikely, possible skin absorption should be considered in meeting the TLV requirements. Vapors of acetone may cause eye irritation while the liquid will cause severe irritation and possibly eye damage. Ingestion of acetone may cause irritation of the gastrointestinal tract and narcosis. The TLV is set to prevent eye and respiratory irritation. FIRST AID: EYE CONTACT: Promptly flush eyes, including under eyelids, with running water for at least 15 minutes. Get medical attention if irritation persists. SKIN CONTACT: Flush exposed skin with running water while removing contaminated clothing. Get medical attention if irritation persists or if exposure is severe. INHALATION: Remove to fresh air. Restore and/or support breathing if required. If effects are more severe than a headache, contact a physician. Consider oxygen therapy. INGESTION: Give victim milk or water. If victim is alert and large amounts have been ingested, induce vomiting by sticking finger to back of throat. Contact a physician or Poison Control Center.</p>		
SECTION 7. SPILL, LEAK AND DISPOSAL PROCEDURES		
<p>Notify safety personnel of large spills or leaks. Remove all sources of heat and ignition. Provide maximum explosion-proof ventilation. Evacuate all personnel from the area, except for those involved in clean-up. Remove leaking container to safe place, if feasible. Absorb small spills on paper towels or vermiculite, evaporate in a fume hood, and place in closed container for disposal. Flush large spills with water spray to clear area of acetone (flush to open ground, <u>not</u> to drains, sewers, or surface water courses) or dilute with >200 parts water and pick up with non-sparking tools for disposal.</p> <p>DISPOSAL: Place in closed containers for disposal by licensed contractor or burn in an approved incinerator. Reduce burning hazards by mixing acetone with a less flammable liquid. Consider reclaiming large quantities of waste acetone, if feasible. Follow all Federal, State and Local regulations.</p> <p>Acetone is considered a hazardous waste by the EPA. The EPA (RCRA) HW No. is: U002 (40 CFR 261).</p>		
SECTION 8. SPECIAL PROTECTION INFORMATION		
<p>Provide general and local exhaust ventilation (explosion-proof) to meet TLV requirements. For emergency or nonroutine exposures where the TLV may be exceeded, use an approved chemical cartridge or canister, gas mask (up to 5000 ppm) or self-contained respirator with full face piece (up to 20,000 ppm). All electrical service in use or storage areas should have an explosion-proof design. Wear safety glasses and butyl rubber or natural rubber gloves to prevent liquid contact with the eyes and skin. Additional protective clothing and equipment (boots, apron, faceshield, respirator) may be necessary to prevent exposure depending on work conditions. Remove contaminated clothing promptly and launder before reuse.</p> <p>An eyewash station and safety shower should be available in use and handling areas. Sprinkler fire protection is desirable in areas of storage, handling and use.</p> <p>NIOSH recommends preplacement and medical exams for those regularly exposed above "action level."</p> <p>Contact lenses pose a special hazard; soft lenses may absorb and all lenses concentrate irritants.</p>		
SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS		
<p>Store in closed containers (carbon steel recommended) in a cool, dry, well-ventilated area away from oxidizing agents, heat, sparks, and open flame. Protect containers from physical damage. Use only with adequate ventilation. Avoid inhalation of vapors and repeated or prolonged contact with the skin. Do not eat or smoke in areas where acetone is being used or handled. Use non-sparking tools.</p> <p>Ground and bond containers and equipment when transferring or pouring acetone to prevent static sparks. Use labeled safety cans when handling small amounts of liquid. Consider storing under a nitrogen pad.</p> <p>DOT CLASSIFICATION: Flammable liquid, UN1090 DOT LABEL: FLAMMABLE LIQUID</p>		
DATA SOURCE(S) CODE (See Glossary) 1-12, 14, 16, 19-21, 23-26, 31, 38, 47, 59, 79.R.		
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	INDUST. HYGIENE/SAFETY <i>11-85</i>	
	MEDICAL REVIEW: <i>Dec 85</i>	

MATERIAL SAFETY DATA SHEET

CORPORATE RESEARCH & DEVELOPMENT

SCHENECTADY, N. Y. 12305

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DIAL COMM: 8*235-4085

MATERIALS
INFORMATION
SERVICES

No. 410

CARBON TETRACHLORIDE

Revision A

Date December 1980

SECTION I. MATERIAL IDENTIFICATION

MATERIAL NAME: CARBON TETRACHLORIDE

OTHER DESIGNATIONS: Tetrachlormethane, Perchlormethane, Methane Tetrachloride, CCl₄, GE Material D5B50, CAS #000 056 235

MANUFACTURER: Available from several suppliers, including:
Linden Chemicals & Plastics

PO Drawer J,
Moundsville, WV 26041

Phone: (314) 843-1310

SECTION II. INGREDIENTS AND HAZARDS

Carbon Tetrachloride

ca 100

HAZARD DATA

8-hr TWA 5 ppm (skin)
or 30 mg/m³*

Human, oral
LD₅₀ 43 mg/kg

Human, inhalation
LC₅₀ 1000 ppm
TC₅₀ 20 ppm (CNS)

Hamsters and mice have
developed cancer on
long term feeding.

*ACGIH (1980 Intended Changes List). OSHA 8-hr TWA is 10 ppm. NIOSH has proposed a 10-hr TWA of 2 ppm. ACGIH and NIOSH recommend labeling as a suspected human carcinogen. (skin) notation indicates absorption through the skin can contribute significantly to overall exposure.

SECTION III. PHYSICAL DATA

Boiling point at 1 atm, deg C --- 76.7 Specific gravity, 25/4 C --- 1.585

Vapor pressure @ 20 C, mm Hg ---- ca 91 Melting point, deg C ----- -23

Vapor density (Air=1) ----- 5.3 Volatiles, % ----- ca 100

Solubility in water @ 20 C, wt % - 0.08 Molecular weight ----- 153.8

Appearance & Odor: A clear, colorless liquid with a characteristic sweetish odor.

Odor recognition threshold (100% of test panel): 21.4 ppm in air when prepared from CS₂; 100 ppm in air when prepared from CH₄. Odor may not be objectionable at acutely toxic levels.

SECTION IV. FIRE AND EXPLOSION DATA

LOWER UPPER

Flash Point and Method

Autoignition Temp.

Flammability Limits In Air

Extinguishing Media: It is nonflammable. Use that which is appropriate for the surrounding fire. Use water spray to cool fire-exposed containers.

When involved in a fire situation, this material will emit highly toxic and irritating fumes and gases. Metals, such as aluminum and magnesium, can react violently with carbon tetrachloride when hot or burning.

Firefighters must wear self-contained breathing apparatus and full protective gear to fight fires involving this material.

SECTION V. REACTIVITY DATA

This material is stable under normal conditions of handling and use. It does not polymerize.

Thermal-oxidative decomposition will produce toxic, corrosive fumes, including phosgene and hydrogen chloride.

Violent reactions or explosions can occur with incompatible materials, such as barium, lithium, sodium, and potassium metal, powdered aluminum, magnesium, dimethylformamide (above 65 C), fluorine, etc. (See NFPA, "Manual of Hazardous Chemical Reactions".)

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SECTION VI. HEALTH HAZARD INFORMATION	TLV 5 ppm (skin) (See Sect. II)
<p>Carbon tetrachloride is highly toxic and irritating by inhalation and ingestion (mean lethal dose is 5-10 ml). It is toxic by skin absorption. Excessive exposure may result in CNS depression and/or gastrointestinal symptoms.* It is irritating to skin and eyes. Eye contact or systemic effects can produce visual disturbances (haze, blind spots, narrowing of visual field, etc.). Skin contacts can cause defatting & dermatitis.</p> <p>Kidney & liver damage can occur from severe acute or chronic exposure. It is a suspected carcinogen in humans.</p> <p style="text-align: center;"><u>FIRST AID:</u></p> <p><u>Eye Contact:</u> Flush eyes with running water for 15 minutes, including under the eyelids. Get medical help if irritation persists or when visual disturbances occur.</p> <p><u>Skin Contact:</u> Remove contaminated clothing promptly. Wash exposed skin with soap and water. Get medical help for repeated or gross exposures.</p> <p><u>Inhalation:</u> Remove to fresh air. Restore and/or support breathing; have qualified person administer oxygen if needed. Get medical help.</p> <p><u>Ingestion:</u> Contact physician for gastric lavage. (If medical help and advice is not readily available, give water to drink and induce vomiting.)</p> <p>*Also cardiac arrhythmias.</p>	
SECTION VII. SPILL, LEAK, AND DISPOSAL PROCEDURES	
<p>Notify safety personnel when large spills occur. Evacuate area. Provide maximum exhaust ventilation. Clean-up personnel must use protection against contact and inhalation (see Sect. VIII). Contain spill; pick up liquid for disposal. Small spills and residues can be absorbed on paper, vermiculite, etc. and allowed to evaporate in a hood. Prevent release of CCl₄ to surface water or sewers. Spills or discharges in 24 hours of 5000 lb or more (proposed RQ* is 1000 lb) must be reported to U.S. Government.</p> <p><u>DISPOSAL:</u> Consider recovery and reuse, if feasible. Scrap may be burned in approved, high temperature incinerator with scrubber or it may be disposed of as hazardous waste (EPA number U211 or F001 as a spent degreasing solvent under RCRA). Follow Federal, State and Local regulations.</p> <p>*Reportable Quantity.</p>	
SECTION VIII. SPECIAL PROTECTION INFORMATION	
<p>Provide general and local exhaust ventilation to meet TLV. Exhaust hoods need 100 fpm min. face velocity. Ventilate sumps and low lying areas. Use air-supplied or self-contained respirators above TLV, with full face piece above 100 ppm.</p> <p>PVA or neoprene gloves and protective clothing needed to prevent skin contact. Wear safety goggles and/or face shield for eye protection.</p> <p>An eyewash station and chemical safety shower should be readily accessible.</p> <p>Provide preplacement and twice a year medical exams. Workers with obesity, diabetes, alcoholism or pulmonary problems should have a physician's approval before working with CCl₄. Retain medical records for 30 years after termination of employment.</p> <p>Provide training to those exposed to CCl₄ in the workplace. Monitor vapor levels in the workplace.</p>	
SECTION IX. SPECIAL PRECAUTIONS AND COMMENTS	
<p>Store in closed containers in a cool, dry, well-ventilated, low fire-risk area.</p> <p>Protect containers against physical damage. Keep away from sources of heat, direct sunlight, and incompatible materials (see Sect. V). Prevent exposure of vapors to high temperature to prevent decomposition to toxic and corrosive gases and vapors. No smoking in areas where vapors may be present.</p> <p>Prevent contact with the skin or eyes. Avoid exposure to vapors. Use good personal hygiene.</p> <p>CCl₄ toxicity is markedly increased by the synergistic effects of alcohol. When possible, substitute a less hazardous solvent for CCl₄.</p> <p>DOT Classification - ORM-A</p> <p>DATA SOURCE(S) CODE: 1-12, 15, 16, 21-26, 31, 37, 38, 41</p>	
<p><small>Judgments as to the suitability of information herein for purchaser's purposes are necessarily purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of such information, General Electric Company extends no warranties, makes no representations and assumes no responsibility as to the accuracy or suitability of such information for application to purchaser's intended purposes or for consequences of its use.</small></p>	<p>APPROVALS: MIS <i>J. M. J. [Signature]</i></p> <p>CRD</p> <p>Industrial Hygiene and Safety <i>[Signature]</i> 12-9-80</p> <p>MEDICAL REVIEW: 16 Dec. 1980</p>


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Material Safety Data Sheet

From Genium's Reference Collection
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GENIUM PUBLISHING CORP.

No. 361
ETHYL ALCOHOL
(Revision B)

Issued: October 1981
Revised: August 1987

SECTION 1. MATERIAL IDENTIFICATION

23

MATERIAL NAME: ETHYL ALCOHOL

DESCRIPTION(Origin/Uses): Used commercially in alcoholic beverages and industrially as a solvent; also as a useful reagent in organic synthesis.

OTHER DESIGNATIONS: Absolute Ethanol; Alcohol, Anhydrous; Alcohol, Dehydrated; Ethanol; Grain Alcohol; Methylcarbinol; C_2H_6O ; NIOSH RTECS #KQ6300000; CAS #0064-17-5

MANUFACTURER/SUPPLIER: Available from several suppliers, including:

Captree Chemical Co., 445 Winding Road, Old Bethpage, NY 11804;

Telephone: (516) 752-9808



HMIS

H 0

F 3

R 0

PPE*

* See sect. 8

R 1

I 1

S 1

K 4

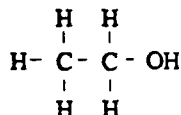
COMMENTS: Ethyl alcohol is a fire and explosion hazard.

SECTION 2. INGREDIENTS AND HAZARDS

%

HAZARD DATA

Ethyl Alcohol, CAS #0064-17-5; NIOSH RTECS #KQ6300000
Water



* The toxicity data given here is a representative list and is by no means exhaustive. In NIOSH RTECS additional toxicity data with references on reproductive, tumorigenic, mutation, and irritation categories are listed.

ACGIH Values 1987-88

TLV-TWA: 1000 ppm, =1900 mg/m³

OSHA PEL 1986

8-Hr TWA: 1000 ppm, 1900 mg/m³

TOXICITY DATA*

Child, Oral, LD₅₀: 2000 mg/kg

Man, Oral, TD₅₀: 50 mg/kg

Man, Oral, TD₅₀: 1430 µg/kg

Woman, Oral, TD₅₀: 256 g/kg (12 Weeks)

SECTION 3. PHYSICAL DATA

Boiling Point ... 173.3°F (78.5°C)

Vapor Pressure ... 43 Torr at 68°F (20°C)

Water Solubility ... 100% (Complete)

Vapor Density (Air = 1) ... 1.6

Specific Gravity ... 0.789 at 68°F (20°C)

Melting Point ... -173.38°F (-114.1°C)

% Volatile by Volume ... ca 100

Molecular Weight ... 46.07 Grams/Mole

Appearance and odor: Colorless, flammable, volatile liquid; burning taste.

COMMENTS: Ethyl alcohol's volatility is an inhalation and fire hazard.

SECTION 4. FIRE AND EXPLOSION DATA

LOWER

UPPER

Flash Point and Method

Autoignition Temperature

Flammability Limits in Air

55°F (12.77°C)

798°F (422.78°C)

% by Volume

3.3%

19%

EXTINGUISHING MEDIA: Use dry chemical, carbon dioxide, alcohol foam, or other appropriate extinguishing agents to fight ethanol fires. A water spray is not recommended as an extinguishing agent, but it can be used to cool fire-exposed metal containers, to dilute and flush spills away from sensitive exposures, to suppress vapors, and to reduce the intensity of fires.

OSHA Flammability Class (29 CFR 1910.106): IB

UNUSUAL FIRE/EXPLOSION HAZARDS: Ethanol is a dangerous fire and explosion hazard with a low flash point, appreciable vapor pressure, and a significant explosive range in air. Exercise due caution when fighting ethanol fires.

SPECIAL FIRE-FIGHTING PROCEDURES: Wear a self-contained breathing apparatus with a full facepiece operated in a pressure-demand or other positive-pressure mode.

DOT Flammability Class (49 CFR 173.115): Flammable Liquid

SECTION 5. REACTIVITY DATA

Ethanol is stable. Hazardous polymerization cannot occur.

CHEMICAL INCOMPATIBILITIES: Hazardous chemical reactions have been reported with oxidizing agents, strong acids, nitrates, perchlorates, peroxides, silver and potassium compounds, and other chemicals.

CONDITIONS TO AVOID include exposure to elevated heat, any possible sources of ignition/explosion, such as heat, sparks, open flame, or lighted tobacco products; and direct physical contact with any chemicals that would produce hazardous reactions.

PRODUCTS OF HAZARDOUS DECOMPOSITION include oxides of carbon, such as carbon monoxide (CO).

SECTION 6. HEALTH HAZARD INFORMATION

Ethanol is not listed as a carcinogen by the NTP, IARC, or OSHA.

SUMMARY OF RISKS: Ethanol vapor, even in low concentrations, is irritating to the eyes and the upper respiratory tract. In setting the TLV-TWA of 1000 ppm ($\approx 1900 \text{ mg/m}^3$), this irritant property of ethanol is more significant than the secondary toxic effects from absorbed or ingested ethanol. Irritation of the eyes and the upper respiratory tract should not occur below concentrations of 5000 ppm; 1000 ppm is close to the odor recognition threshold of ethanol. Inhalation of ethanol vapors can have effects similar to those characteristic of ingestion. These include an initial stimulatory effect followed by symptoms of mental excitement, drowsiness, impaired vision, ataxia, stupor, and drunkenness as the amount consumed increases. Large ingested doses can deleteriously affect the GI tract and the central nervous system. Contact with eyes causes an immediate burning and stinging sensation. Prolonged or repeated skin contact causes defatting and dermatitis.

TARGET ORGANS: Eyes, skin, respiratory system, and hepatic system. **PRIMARY ENTRY:** Inhalation, ingestion, skin contact. **ACUTE EFFECTS:** Ataxia, incoordination, drowsiness, local irritating effects on the eyes, headache, intraocular tension, stupor, fatigue, and a great need for sleep. **CHRONIC EFFECTS:** None reported. **MEDICAL CONDITIONS AGGRAVATED BY LONG-TERM EXPOSURE:** include liver damage and chronic irritation of the mucous membranes and the skin.

FIRST AID: EYE CONTACT: Immediately flush eyes, including under the eyelids, gently but thoroughly with plenty of running water for at least 15 minutes. Get medical help.* **SKIN CONTACT:** Wash thoroughly with soap and water. Remove and launder contaminated clothing before wearing it again; clean material from shoes and equipment. Get medical help.* **INHALATION:** Remove victim to fresh air; restore and/or support his breathing as needed. Get medical help.*

INGESTION: Call a poison control center. Never give anything by mouth to someone who is unconscious or convulsing. Get medical help.*

* **GET MEDICAL ASSISTANCE = IN PLANT, PARAMEDIC, COMMUNITY.** Get prompt medical assistance for further treatment, observation, and support after first aid.

COMMENTS: Individual tolerance, amount of rest, medication, and daily eating habits are just some of the contributing factors that determine a worker's response to ethanol exposure. Provide physical examinations emphasizing the lungs, skin, the respiratory system and hepatic system to workers who are exposed to ethanol.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

SPILL/LEAK: Notify safety personnel of spills or leaks of ethanol. Provide maximum explosion-proof ventilation. Eliminate all possible sources of heat or ignition; if feasible, remove any leaking container to an open area. Cleanup personnel need protection against inhalation and skin contact. Use nonsparking tools during all cleanup procedures. Contain spill and pick up liquid for recovery or disposal when feasible. Absorb small spills with dry sand, vermiculite, or other suitable material. Consider diluting a spill with water to raise the material's flash point. **DISPOSAL:** Consider reclamation, recycling, or destruction rather than disposal in a landfill. Filtration and distillation procedures may help reclamation operations. Contact your supplier or a licensed waste-disposal contractor for detailed recommendations. Follow Federal, state, and local regulations.

Ethanol is not designated as a hazardous substance by the EPA (40 CFR 116.4)

Ethanol is reported in the 1983 EPA TSCA Inventory.

EPA Hazardous Waste No. (40 CFR 261.21, Ignitability): D001

EPA Reportable Quantity (40 CFR 117.3): Not Listed

Aquatic Toxicity TLM 96: Over 1000 ppm

SECTION 8. SPECIAL PROTECTION INFORMATION

GOGGLES: Always wear protective eyeglasses or chemical safety goggles. Follow the eye and face protection guidelines of 29 CFR 1910.133. **GLOVES:** Wear impervious gloves. **RESPIRATOR:** Follow the respirator guidelines in 29 CFR 1910.134. IDLH or unknown concentrations require an SCBA, full facepiece, and pressure-demand/positive-pressure modes. **WARNING:** Air-purifying respirators will not protect workers from oxygen-deficient atmospheres. **OTHER**

EQUIPMENT: Wear rubber boots, aprons, and other appropriate personal protective equipment suitable to the work situation. **VENTILATION:** Use and operate both general and local exhaust ventilation systems that are of sufficient power to maintain airborne levels of ethanol below the legislated OSHA PEL cited in section 2. Local exhaust hoods should have a minimum face velocity of 100 fpm. All ventilation systems should be nonsparking and of maximum explosion-proof design. **SAFETY**

STATIONS: Make eyewash stations, washing facilities, and safety showers available in areas of use and handling. Contact lenses pose a special hazard; soft lenses may absorb irritants, and all lenses concentrate them. **SPECIAL CONSIDERATIONS:** All engineering systems and operations should be made explosion proof by eliminating mechanical or electrical sparks, open flame, and uncovered or unprotected heating elements. **COMMENTS:** Practice good personal hygiene. Keep material off of your clothes and equipment. Avoid transferral of material from hands to mouth while eating, drinking, or smoking. Do not smoke anywhere near the work areas where ethanol is used!

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

STORAGE SEGREGATION: Separate ethanol in tightly closed containers in a cool, dry, well-ventilated area away from chemically incompatible materials. Do not expose it to direct sunlight or sources of heat or ignition. **SPECIAL**

HANDLING/STORAGE: Electrically ground and bond all containers involved in storage or transferring operations to prevent static sparks. Use nonsparking tools. Protect containers from physical damage. Storage and use conditions must be suitable for an OSHA class 1B flammable liquid. **ENGINEERING CONTROLS IN THE WORKPLACE:** Use ethanol only with adequate ventilation. **COMMENTS:** Avoid repeated or prolonged skin contact or inhalation of vapors. Use only with adequate ventilation and eliminate all sources of hazardous or unintended ignition. Exposure to ethanol enhances toxicity hazards of other materials such as chlorinated hydrocarbon solvents or drugs.

TRANSPORTATION DATA (per 49 CFR 172.101-2):

DOT Hazard Class: Flammable Liquid

DOT ID No. UN1170

IMO Class: 3.2

IMO Label: Flammable Liquid

DOT Shipping Name: Ethyl Alcohol

DOT Label: Flammable Liquid

References: 1, 2, 4-12, 16, 20, 23-26, 34, 37, 38, 42, 47, 73, 87-94. PI

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Approvals *JOACROCCO*

Indust. Hygiene/Safety *SPW 12/87*

Medical Review *PH/H 12/87*

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MATERIAL SAFETY DATA SHEET
GENTUM PUBLISHING CORPORATION
 1145 CATALYN ST., SCHENECTADY, NY 12303 USA (518) 377-8854



MSDS # G 354

METHYL ALCOHOL
 Revision C

Issued:

Revised: September, 1985

From Gentum's MSDS Collection, to be used as a reference.

SECTION 1. MATERIAL IDENTIFICATION

17

MATERIAL NAME: METHYL ALCOHOL

OTHER DESIGNATIONS: Methanol, Wood Alcohol, Carbinol, Wood Naphtha, Methyl Hydroxide, Monohydroxy Methane, CH₃OH, CAS #67-56-1

MANUFACTURER/SUPPLIER: Available from several suppliers, including: E.I. DuPont DeNemours & Co. (302- 774-2290)
 Chemicals & Pigments Dept (800) 441-9442
 1007 Market St. Wilmington, DE 19898



SECTION 2. INGREDIENTS AND HAZARDS

METHYL ALCOHOL



* Current OSHA Standard; ACGIH (1985-86) TLV adds (skin) notation.

NIOSH has recommended a TWA standard of 200 ppm with a fifteen minute ceiling of 800 ppm. This ceiling is well above the TLV STEL of 250 ppm.

%

ca 100

HAZARD DATA

8 hr TWA: 200 ppm, or
 260 mg/m³ (Skin)
 STEL: 250 ppm, or
 310 mg/m³

 HUMAN
 Eye: 5 ppm, primary
 irritation dose

 Oral: LDLo: 340 mg/kg
 Inhalation: TCLo: 86,000
 mg/m³ - Toxic irritant
 effects (systemic)

SECTION 3. PHYSICAL DATA

Boiling Point, 1 atm 148.5°F (64.7°C)
 Vapor density (Air=1) 1.11
 Vapor pressure @ 21°C, mmHg ... 100
 @ 50°C, mmHg ... 400
 Water Solubility Totally Miscible

Viscosity @ 20°C, cps 0.59
 Specific gravity, 20°/4°C ... 0.791
 Melting point -144°F (-97.8°C)
 Volatiles, % ca 100
 Evaporation rate (BuAc=1) ... 5.9
 Molecular weight 32.04

APPEARANCE & ODOR: Clear, colorless, highly polar liquid with a characteristic alcohol odor. The odor recognition threshold (100% of test panel) is 53.3 ppm

SECTION 4. FIRE AND EXPLOSION DATA

Lower

Upper

Flash Point and Method	Autoignition Temp.	Flammability Limits in Air		
60.8°F (12°C) Closed Cup	725°F (385°C)	% by Volume	6	36.5

EXTINGUISHING MEDIA: Use carbon dioxide, dry chemical, or alcohol type foam. Do not use a solid stream of water since the stream will scatter and spread the fire. Use water spray to cool fire-exposed tanks/containers. Fires involving Methyl Alcohol are Class IB; use a blanketing effect to smother fire. Methyl Alcohol is a moderate explosion hazard and a dangerous fire hazard when exposed to heat, sparks, flame or oxidizers. Its vapors are heavier than air and may travel a considerable distance to an ignition source and flashback. Firefighters should wear self-contained breathing apparatus and full protective clothing when fighting fires involving Methyl Alcohol.

SECTION 5. REACTIVITY DATA

Methyl Alcohol is stable in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization. This material may react violently with chromic anhydride; iodine plus ethyl alcohol, and mercuric oxide; lead perchlorate; perchloric acid plus ethyl alcohol; dimethyl formamide plus phosphorous; potassium hydroxide plus chloroform; sodium hydroxide plus chloroform. It may also react with metallic aluminum at high temperatures. Methyl Alcohol is incompatible with strong oxidizing agents (eg., nitrates, perchlorate or sulfuric acid), active metals, acetaldehyde, ethylene oxide, isocyanates, beryllium dihydride, chloroform, and potassium tert-butoxide. It may attack some forms of plastics and rubber. Thermal decomposition or burn will produce carbon monoxide, carbon dioxide and possible toxic formaldehyde and unburned methanol.

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SECTION 6. HEALTH HAZARD INFORMATION

TLV 200 ppm (skin) or 260 mg/m³

Methanol is a poisonous, narcotic chemical that may exert its effects through inhalation, skin absorption, or ingestion. Elimination of Methanol from the body is slow, and the toxic effects can be compounded by repeated excessive exposures over several days. Toxic effects are exerted upon the CNS, especially the optic nerve and possibly the retinae. Symptoms of overexposure include dizziness, visual impairment, nausea, respiratory failure, muscular incoordination and narcosis. Visual disturbances may clear temporarily then re-occur and progress to blindness. Prolonged or repeated contact with the skin may cause dermatitis, erythema, and scaling. Vapors of Methanol are mildly irritating to the eyes, while direct contact with the liquid may cause irritation, pain and transient corneal opacity. Ingestion of Methanol can cause blindness and death. The fatal dose is 100-250 ml, although death from ingestion of less than 33 ml has been reported.

FIRST AID: **EYE CONTACT:** Immediately flush eyes, including under eyelids, with plenty of running water for at least 15 minutes. Get medical attention if irritation persists. **SKIN CONTACT:** Flush exposed area with water while removing contaminated clothing. Wash with soap and water. Get medical attention if irritation persists.

INHALATION: Remove victim to fresh air. Restore and/or support breathing as needed. Get medical help (Inplant Paramedic, community). **INGESTION:** Give victim 3-4 glasses of water or milk and induce vomiting by sticking finger to back of throat. Contact a Poison Control Center or physician. Transport victim to a medical facility immediately. Do not induce vomiting or give anything to drink if victim is unconscious or having convulsions. Get medical attention (Inplant, paramedic, community).

SECTION 7. SPILL, LEAK AND DISPOSAL PROCEDURES

Notify safety personnel of large spills or leaks. Remove all sources of heat and ignition. Provide maximum explosion-proof ventilation. Evacuate all personnel from the area except for those involved in clean-up. Remove leaking container to safe place if feasible. Clean-up personnel should wear protective clothing, gloves, boots, and a self-contained breathing apparatus. Absorb small quantities on paper towel, vermiculite, or other absorbent and place in closed container for disposal. Dike large spills and collect for reclamation or disposal. Water spray may be used to knock down vapor and to dilute and flush spill away from sensitive areas. Do not flush to sewer. Keep out of watersheds and waterways.

DISPOSAL: Place in suitable container for disposal by a licensed contractor or burn in an approved incinerator. Waste solvent may be reclaimed via filtration and distillation procedures. Methyl Alcohol has been designated as a hazardous waste by the EPA (RCRA CFR 261.33). The EPA Hazardous Waste No. is U154. Aquatic Toxicity Rating: TL-95: Over 1000 ppm.

SECTION 8. SPECIAL PROTECTION INFORMATION

Provide general and local exhaust ventilation (explosion-proof) to meet TLV requirements. For emergency or non-routine exposures where the TLV may be exceeded, wear an appropriate NIOSH-approved respirator. All electrical service in use or storage areas should have an explosion-proof design. Prevent skin and eye contact by wearing rubber gloves and splash goggles or safety glasses. Use protective aprons, boots and face shield as necessary when splashing may occur. Eyewash stations and safety showers should be available in areas of use and handling. Provide suitable training to those working with Methanol. Monitor the workplace and keep accurate records.

Contact lenses pose a special hazard; soft lenses may absorb and all lenses concentrate irritants.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store in tightly closed containers in a dry, well-ventilated area away from strong oxidizing agents, heat, sparks and open flame. Protect container from physical damage. When transferring or pouring Methyl Alcohol, ground and bond containers and equipment to prevent static sparks. Use non-sparking tools. Do not smoke in areas of use or storage. Use with adequate ventilation. Do not breathe vapors. Avoid contact with eyes and skin. This material is poisonous when introduced into the body metabolism. **DO NOT INGEST!!!** Provide preplacement medical exams and periodic medical surveillance for industrially exposed workers with emphasis on neurological and visual functions, liver, and kidney systems.

DOT CLASSIFICATION: Flammable liquid, UN1230

DOT LABEL: Flammable liquid.

DATA SOURCE(S) CODE (See Glossary) 1, 2, 4-12, 16, 19, 20, 23-26, 31, 34, 37-39, 43, 47, 63, 79. R.

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APPROVALS

JC Rourke, 11/85

INDUST. HYGIENE/SAFETY

SW 11-85

MEDICAL REVIEW:

[Signature] Dec 85

MATERIAL SAFETY DATA SHEET

GENIUM PUBLISHING CORPORATION
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(518) 377-8854



NO. 310

METHYLENE CHLORIDE

Revision D

DATE December 1984

SECTION I. MATERIAL IDENTIFICATION

MATERIAL NAME: METHYLENE CHLORIDE

OTHER DESIGNATIONS: Dichloromethane, Methane Dichloride, CH_2Cl_2 , ASTM D3506,
CAS #000 075 092, GE Material D5B89.

MANUFACTURER: Available from many suppliers, including Dow Chemical Co.;
Diamond Shamrock Corp.; Electrochemicals Div.; and Vulcan Chemicals.

SECTION II. INGREDIENTS AND HAZARDS

Methylene Chloride

*ACGIH (1984) TLV. OSHA PEL is 500 ppm with a 1000 ppm
Ceiling level and a maximum peak ceiling concentration
(5 min. in any 2 hours) of 2,000 ppm.

NIOSH has proposed a 75 ppm 10 hr-TWA with a ceiling con-
centration of 500 ppm. (15 minute sample). NIOSH also
warns that toxic hazards with CH_2Cl_2 are increased by
the presence of alcohol and/or carbon monoxide and
by heavy labor and smoking.

%

Ca 100

HAZARD DATA

8-hr TWA 100 ppm
or 350 mg/m³*

Human, Inhalation
TCLo 500 ppm/8-hr
(Blood Effects)

TCLo 500 ppm/1 Yr-I
(CNS Effects)

Rat, Oral

LD₅₀ 2524 mg/kg

SECTION III. PHYSICAL DATA

Boiling point, 1 atm deg F (C)	----- 104 (40)	Specific gravity, 25/25C	---- 1.32
Vapor pressure at 20 C, mm Hg	----- 340	Volatiles, %	----- ca 100
Vapor density (Air=1)	----- 2.9	Evaporation rate ($\text{CCl}_4=1$)	---- 1.47
Solubility in water, wt. % at 20C	--- ~1.6	Freezing point, deg C	----- -96
		Molecular weight	----- 84.94

Appearance & Odor: Colorless liquid; penetrating ether-like, sweetish odor.
The recognition threshold (unfatigued) is 214 ppm, 100% of test panel.

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits in Air	Lower	Upper
None (TCC)	>1033 F (556C)	Vol. % at 100 C	>12	*

Nonflammable and nonexplosive under normal conditions of use. However, its high vapor
pressure can give substantial vapor conc. rapidly during a spill.

It forms weakly combustible mixtures in air when heated; it can burn or explode in
oxygen-enriched air. Control fires with carbon dioxide, dry chemicals, or water
fog. Cool containers with water spray to prevent pressure rupture.

Firefighters should use self-contained breathing apparatus (with eye protection) for
protection from suffocating and intoxicating vapors and thermal decomposition
products. Vapors can flow to low lying areas.

*UEL reported as high as ~66% (high-oxygen atmospheres).

SECTION V. REACTIVITY DATA

Methylene chloride is a stable compound under normal conditions of storage and use.

It does not undergo hazardous polymerization.

In oxygen-enriched atmospheres or when heated (>100C) it can be readily ignited. Ex-
posure to high temperatures (open flames, hot surfaces, welding arcs, etc.) can give
corrosive and toxic thermal-oxidative decomposition products, such as hydrogen
chloride and small quantities of phosgene.

Prolonged exposure to excess water may cause noticeable hydrolysis above 60 C.

Prevent contact with alkali metals (for example: Na, K, Li, NaK), potassium tert-butoxide
and finely powdered aluminum and magnesium to avoid possible violent reactions.

SECTION VI. HEALTH HAZARD INFORMATION		TLV 100 ppm (See Sect II)
<p>Methylene chloride is a mild CNS depressant. Body entry mainly by inhalation and skin absorption. Excessive inhalation [300-700 ppm for 3-5 hrs] causes slight loss of coordination and equilibrium. Overexposure can be irritating to the eyes, skin and respiratory tract. Symptoms can also include dizziness, nausea, tingling of extremities, stupor, and lethargy. Severe exposure may cause unconsciousness and death. Prolonged or repeated skin contact may cause redness, irritation and dermatitis. Eye contact can be painful and irritating.</p> <p>It is stored in body fat and metabolizes to carbon monoxide, which increases & sustains carboxyhemoglobin levels in the blood reducing its oxygen-carrying capacity.</p> <p>FIRST AID:</p> <p>Eye or Skin Contact: Remove contaminated clothing. Flush contact area (including under eyelids) with plenty of running water for 5-15 min. If irritation persists get medical attention.</p> <p>Inhalation: Remove to fresh air. Restore and/or support breathing (O₂ therapy) as required. Keep warm and at rest. Get medical help. Advise physician <u>not</u> to use adrenalin.</p> <p>Ingestion: Get prompt medical help! Do not induce vomiting. If vomiting occurs spontaneously, position victim's head below trunk to resist aspiration hazard. Advise physician <u>not</u> to use adrenalin.</p>		
SECTION VII. SPILL, LEAK, AND DISPOSAL PROCEDURES		
<p>For small spills, soak up with an absorbent solid, such as paper or vermiculite, avoiding breathing of vapors and using gloves to avoid contact. Evaporate off solvent in an exhaust hood or open area if allowable.</p> <p>When large spills occur, evacuate area; eliminate ignition sources; notify safety personnel; provide ventilation; stop leakage. Clean up personnel need protection against contact and inhalation. Contain and recover liquid when possible. Pick up residue with absorbant (as with small spills) or flush to ground (not to sewer) to evaporate.</p> <p>DISPOSAL: Reclaim waste solvent by filtration and distillation procedures or dispose of via a licensed, waste solvent disposal company.</p> <p>AQUATIC TOXICITY RATING TLM 96: 1000-100 ppm.</p>		
SECTION VIII. SPECIAL PROTECTION INFORMATION		
<p>Use general and efficient exhaust ventilation to meet TLV requirements including floor level, and sump ventilation. Air-supplied or self-contained breathing apparatus should be available for emergency use with a full facepiece needed above 750 ppm. This is a highly volatile liquid.</p> <p>Use neoprene, PVA, or Viton gloves for skin protection. Chemical goggles and/or faceshield should be used where splashing is possible. An eyewash station and safety shower should be readily available if splashing is probable.</p> <p>NOTE: CO and CH₂Cl₂ content of workplace air are additive and both must be monitored where methylene chloride exposures occur. The 10-hr TWA of 9 ppm for CO must be met where exposure to CH₂Cl₂ occurs unless CH₂Cl₂ exposure is held at a lower level than the TLV.</p> <p>Preplacement and annual physical exams should emphasize the nervous and respiratory systems, liver, kidneys, skin, eyes and carboxyhemoglobin levels. Those with a history of cardiovascular disease or who are heavy drinkers or smokers should avoid exposure to methylene chloride.</p>		
SECTION IX. SPECIAL PRECAUTIONS AND COMMENTS		
<p>Store in closed containers in a cool, well-ventilated area away from sources of heat and combustibles. Open containers with caution.</p> <p>Use caution in handling this material. Avoid airborne concentration build-up. Avoid exposure to high temperature. No smoking where vapors of this material are present.</p> <p>Avoid prolonged or repeated skin contact. Protect containers from physical damage.</p> <p>When methylene chloride vapors are drawn into the combustion chamber of a space heater, severe corrosion damage to the heater can occur, even at levels well below the TLV.</p> <p>IARC Review (1979) listed animal carcinogenic determination as indefinite.</p> <p>A substantial risk notice to EPA (TSCA, 8e) reports a high incidence of lung and liver tumors in mice in long term inhalation studies at 2000-4000 ppm (1984, preliminary).</p> <p>DOT Classification: ORM-A DOT I.D. No. UN1593 Label: NONE (or St. Andrews Cross)</p> <p>IMO Class: 6.1</p> <p>DATA SOURCE(S) CODE: 1-12, 14, 16, 23, 25, 31, 34, 37, 38, 47, 48</p>		
<p>Judgments as to the suitability of information herein for purchaser's purposes are necessarily purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of such information, Genium Publishing Corporation extends no warranties, makes no representations and assumes no responsibility as to the accuracy or suitability of such information for application to purchaser's intended purposes or for consequences of its use.</p>		<p>APPROVALS: MIS CRD <i>J. M. V. [Signature]</i></p> <p>INDUST. HYGIENE SAFETY <i>[Signature]</i> 12-4-84</p> <p>MEDICAL REVIEW: December 1984</p>

GENIUM PUBLISHING

MATERIAL SAFETY DATA SHEET

CORPORATE RESEARCH & DEVELOPMENT
120 ERIE BOULEVARD
SCHENECTADY, N.Y. 12305

MATERIALS
IS
INFORMATION SERVICES

NO. 311
INHIBITED
1,1,1-TRICHLOROETHANE
REVISION D
DATE August 1983

SECTION I. MATERIAL IDENTIFICATION

MATERIAL NAME: INHIBITED 1,1,1-TRICHLOROETHANE
OTHER DESIGNATIONS: Methyl Chloroform, MC, CCl_3CH_3 , GE Material D5B79, CAS# 000 071 556,
 α -Trichloroethane
TRADE NAMES & BLACO-THANE (Baron-Blakeslee), CHLOROTHENE NU & VG (Dow), INHIBISOL
MANUFACTURER: (Penetone Corp.), TRI-ETHANE (PPG Ind. Inc.), TRITHENE (SRS, Inc.)

SECTION II. INGREDIENTS AND HAZARDS

	%	HAZARD DATA
1,1,1-Trichloroethane	>95	8-hr TWA 350 ppm**
Inhibitor, typical*	< 5	Unknown
*Inhibitors used are proprietary. Commercial materials contain up to about 5% inhibitor and are designed for cold cleaning or vapor degreasing use or both.		Human, Inhalation LCLo 27 gm/m ³ /10 min
**Current OSHA PEL and ACGIH (1983) TLV. ACGIH STEL 450 ppm.		TCLo 920 ppm/70 min (CNS effects)
NIOSH (1976) proposed a 10-hr TWA of 200 ppm with a 350 ppm ceiling (15 minute sample) and has recommended caution in use		Human, Oral TDLo 670 mg/kg (GI effects)

SECTION III. PHYSICAL DATA

Boiling point, 1 atm, deg F ----- ca 165* Specific gravity, 25/25C --- 1.3-1.336*
Vapor pressure, 20 C, mm Hg ----- 100 Volatiles, % ----- ca 100
Vapor density (Air=1) ----- 4.55 Melting point, deg C ----- -32
Water solubility, g/100ml H₂O @20C - 0.09 Evaporation rate (CCl₄=1) -- 1
Molecular weight ----- 133.41

Appearance & Odor: Colorless liquid with a mild, sweetish, pleasant, ether-like odor which may be just perceptible (unfatigued) at about 100 ppm in air.
*Properties depend on the inhibitor and inhibitor level.

SECTION IV. FIRE AND EXPLOSION DATA

Flash Point and Method	Autoignition Temp.	Flammability Limits in Air	Lower	Upper
None	537 C (998 F)	(High energy ignition source at 25C). Vol. %	8.0%	10.5%

This material is nearly nonflammable. High energy, such as electric arc, is needed for ignition, and the flame tends to go out when the ignition source is removed. Material involved in a fire can emit toxic and irritating fumes. Water fog, carbon dioxide, dry chemical, or foam may be used to fight fires.

Use self-contained or air-supplied breathing apparatus for protection against suffocating vapors and toxic and corrosive decomposition products.

SECTION V. REACTIVITY DATA

This material can be hydrolyzed by water to form hydrochloric acid and acetic acid. It will react with strong caustic, such as caustic soda or caustic potash to form flammable or explosive material. Attacks natural rubber.

It requires inhibitor content to prevent corrosion of metals; and when inhibitor is depleted, it can decompose rapidly by reaction with finely divided white metals, such as aluminum, magnesium, zinc, etc. Do not use these metals for storage containers or in pressurized spraying equipment where MC is involved.

It will decompose at high temperature upon contact with hot metal, or under ultra-violet radiation to produce toxic and corrosive gases (hydrogen chloride, dichloroacetylene, chlorine and some phosgene).

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SECTION VI. HEALTH HAZARD INFORMATION		TLV 350 ppm or 1900 mg/m ³
<p>Brief exposure at 900-1000 ppm causes mild eye irritation and loss of coordination due to the early effects of MC on the CNS. Excessive exposure gives headache, drowsiness, impaired judgement, unconsciousness. Defats skin on contact, can produce irritation and dermatitis; can be absorbed through the skin. Eye contact gives pain and irritation. Considered low in toxicity among the chlorinated hydrocarbons.</p> <p>FIRST AID: <u>Eye contact:</u> Flush eyes well with plenty of running water for 15 min, including under eyelids. <u>Skin contact:</u> Remove solvent-wet clothing promptly. Wash contact area with warm water and soap. Get medical attention for irritation. <u>Inhalation:</u> Remove to fresh air. Restore and/or support breathing as needed. Get medical assistance. (Note: Advise physician not to use adrenalin.) <u>Ingestion:</u> Contact physician. Aspiration a hazard! Possible spontaneous vomiting. (If medical help not readily available and amount swallowed was appreciable, give milk or water to drink and induce vomiting. Repeat. Estimated lethal dose for 150 lb man is 0.5 to 1 pint.) PHYSICIAN: Avoid using sympathomimetic amines in treatment.</p>		
SECTION VII. SPILL, LEAK, AND DISPOSAL PROCEDURES		
<p>For small spills in ventilated area, mop, wipe or soak up with absorbent material avoiding inhalation and contact. Evaporate outdoors or in an exhaust hood. For large spills, inform safety personnel and evacuate area. Use protective equipment during clean-up (see Sect. VIII). Ventilate area. Contain liquid, pick up and place in closed metal containers. Do not allow to enter drains and water ways. DISPOSAL: Dispose of via a licensed waste solvent disposal company, or reclaim by filtration and distillation procedures. Follow Federal, State and Local regulations. Aquatic toxicity TLM 96: 100-10 ppm. EPA hazardous waste number under RCRA is U226 (40CFR261).</p>		
SECTION VIII. SPECIAL PROTECTION INFORMATION		
<p>Provide general and local exhaust ventilation to meet TLV requirements. Air-supplied or self-contained respirator should be available for non-routine or emergency use. A chemical cartridge-type respirator can be used for a limited time below 1000 ppm. A full facepiece is needed above 500 ppm. Chemical goggles or a face shield should be worn if splashing is possible. Gloves and apron (of neoprene, polyethylene or polyvinyl alcohol) should be worn when needed to avoid skin contact. Remove solvent-wet clothing promptly. A safety shower and eyewash station should be available to use area if splashing is probable. Preplacement and periodic medical examinations should consider cardiovascular, liver, CNS functions, and skin.</p>		
SECTION IX. SPECIAL PRECAUTIONS AND COMMENTS		
<p>Store in closed containers in a cool, well-ventilated area. Keep water-free. Monitor inhibitor level for vapor degreasing use. Use caution in cleaning operations involving white metal fines (see Sect. V). Trichloroethylene contamination may cause decomposition when aluminum is degreased. Provide medical monitoring of those regularly exposed to MC in the workplace. Preclude those with CNS, liver, or heart disease from exposure. Personnel using this solvent should avoid drinking alcoholic beverages shortly before, during, or soon after exposure. NIOSH (1976 Crit. Doc.) expressed concern because of possible birth defects from high level pregnant rat exposures. Since 1976, directed studies have been negative. At occupational physicians' seminar on "Reproductive Hazards in the Workplace," Washington, DC (4/25/83), no physician was aware of data to substantiate the NIOSH concern. DOT Classification: ORM-A I.D. No. UN2831 DATA SOURCE(S) CODE: 1-12, 14, 20, 23, 25, 26, 30, 31, 34, 37, 38, 45-49, 53</p>		
<small>Judgments as to the suitability of information herein for purchaser's purposes are necessarily purchaser's responsibility. Therefore, although reasonable care has been taken in the preparation of such information, General Electric Company extends no warranties, makes no representations and assumes no responsibility as to the accuracy or suitability of such information for application to purchaser's intended purposes or for consequences of its use.</small>		APPROVALS: MIS/CRD <i>J. M. Nelson</i> INDUST. HYGIENE/SAFETY <i>JW 7/21/83</i> MEDICAL REVIEW: 1 August 1983

GENERAL  ELECTRIC



SECTION 1. MATERIAL IDENTIFICATION			19	
MATERIAL NAME: TRICHLOROTRIFLUOROETHANE				
OTHER DESIGNATIONS: 1,1,2-Trichloro-1,2,2-Trifluoroethane, $\text{FC}_2\text{ClCClF}_2$; CAS #0076-13-1.				
TRADE NAMES: All registered, ARKLONE P-113 (Alpha Metals); BLACO-TRON TF (Baron-Blakeslee); FREON TF, FREON 113 (du Pont); FRIGEN 113TR-T (Hoechst AG); GENETRON 113, GENESOLV D (Allied Corp.); ISOTRON 113, REFRIGERANT 113 (Pennwalt Corp.); UCON 113 (Union Carbide).			HMIS H: 1 F: 0 R: 0 PPE: * * See Sect. 8	
MANUFACTURER: Available from many suppliers, including: SCM Specialty Chemical, PO Box 1466, Gainesville, FL 32602; Telephone: (800) 331-6313				
SECTION 2. INGREDIENTS AND HAZARDS		%	HAZARD DATA	
TRICHLOROTRIFLUOROETHANE • Current OSHA PEL and ACGIH (1985-86) TLV.		ca 100	8-hr TWA 1000 ppm or 7600 mg/m^3 * ----- Human, Inhalation, TClO: 4500 ppm (Central Nervous System) ----- Rat. Oral, LDLo: 45 mg/kg	
SECTION 3. PHYSICAL DATA				
Boiling Point, 1 atm ... 117.6°F (47.6°C) Vapor Pressure @ 70°F, mm Hg ... 285 Vapor Density (Air = 1) ... ca 6 Solubility in H_2O @ 70°F, % ... 0.028		Specific Gravity (20/4°C) ... 1.57 Volatiles, % ... ca 100 Evaporation Rate (Acetone = 1) ... 0.45 Melting Point ... -35°C to -36°C Molecular Weight ... 187.39		
Appearance and odor: Clear, colorless liquid with a slight ethereal odor whose recognition threshold (100% of test panel for UCON-113) is 135 ppm in air. (Vapor may be detected below 50 ppm, unfatigued.)				
SECTION 4. FIRE AND EXPLOSION DATA			LOWER	UPPER
Flash Point and Method	Autoignition Temp.	Flammability Limits In Air	NA	NA
NA	NA	NA	NA	NA
EXTINGUISHING MEDIA: Use whatever is appropriate for surrounding fire. This is a nonflammable material. Vapors are five times heavier than air. High concentrations may tend to accumulate in low-lying areas. Very high concentrations can dilute available oxygen in the air below levels necessary to sustain life.				
Fire fighters should wear self-contained breathing apparatus and fully protective clothing against suffocating vapors and toxic and corrosive products of decomposition.				
SECTION 5. REACTIVITY DATA				
This is a very stable material in closed containers at room temperature under normal storage and handling conditions. It does not undergo hazardous polymerization.				
Prevent exposure to alkali or alkaline earth metals such as sodium, potassium, etc. Aluminum, zinc, magnesium, and beryllium may also be reactive, especially in the finely ground or powdered state or at high temperatures.				
Thermal-oxidative degradation can produce toxic and corrosive materials such as halogens, halogen acids, and carbonyl halides.				

SECTION 6. HEALTH HAZARD INFORMATION | TLV

High concentrations of trichlorotrifluoroethane vapors may cause asphyxiation due to dilution of available oxygen in air below levels necessary to sustain life. Exposures greater than 2500 ppm can produce central nervous system depression, with psychological and psychomotor interference (disorientation and incoordination). Symptoms can include lightheadedness, giddiness, disorientation, shortness of breath, and possible cardiac arrhythmias. Vapors may have little or no effect on the eyes, but liquid contact may cause irritation and mild conjunctivitis. Repeated or prolonged contact with skin may cause defatting and possible dermatitis.

Trichlorotrifluoroethane has not been listed as a carcinogen by the NTP, IARC, or OSHA.

FIRST AID: EYE CONTACT: Flush thoroughly with running water for 15 minutes (including under eyelids). **SKIN**

CONTACT: Remove contaminated clothing. Flush affected area with water. Treat for frostbite if symptoms are present.

INHALATION: Remove to fresh air. Restore and/or support breathing as needed. If products of thermal-oxidative decomposition (see Sect. 5) have been inhaled, observe victim for signs of pulmonary edema.

INGESTION: Seek physician. Seek prompt medical assistance for further treatment, observation, and support.* DO NOT USE epinephrine or similar drugs, for they can produce cardiac arrhythmias, including ventricular fibrillation.

* GET MEDICAL HELP = In plant, paramedic, community.

SECTION 7. SPILL, LEAK, AND DISPOSAL PROCEDURES

Notify safety personnel of leaks or spills. Remove sources of heat or ignition. Provide adequate ventilation. Cleanup personnel to use self-contained respirator and protective clothing. Stop leakage if possible; remove leaking containers to safe area for discharge and allow to evaporate in an area remote from buildings and people. Residues or small spills can be picked up with an absorbent (vermiculite, dry sand) and placed in a covered metal container for disposal.

DISPOSAL: Material can be reclaimed by filtration and distillation process or disposed of by a licensed solvent waste disposal firm. Avoid discharge to environment when possible. Return scrap to supplier, if possible. Follow Federal, state, and local regulations.

SECTION 8. SPECIAL PROTECTION INFORMATION

Provide adequate mechanical ventilation to keep vapors below the TLV level. Supply ventilation for sumps and low-lying areas where the dense vapors of this material may collect. Local exhaust should be used where large amounts are released. Use approved self-contained or air-supplied breathing apparatus and lifelines for emergencies. Use chemical safety goggles and/or face shield to prevent liquid contact with eyes where splashing is possible. Wear neoprene or polyvinyl alcohol gloves and clothing appropriate for the work situation to minimize skin contact with liquid.

Eyewash stations and safety showers should be readily accessible near areas of use.

Contact lenses may pose a special hazard; soft lenses may absorb and all lenses concentrate irritants.

Vaporization of excessive amounts can displace oxygen necessary for breathing and may cause suffocation when used in confined spaces or areas without ventilation. Make sure that confined or enclosed spaces are safe prior to entry.

SECTION 9. SPECIAL PRECAUTIONS AND COMMENTS

Store in closed, steel, containers in a cool (below 125°F), dry, well-ventilated area away from open flame, arc welding, and high-temperature surfaces. Protect containers from physical damage. High-density vapors may displace air and present an asphyxiation hazard. Concentrations well below the TLV level can damage space heaters when drawn into the combustion chamber. Heater should have independent air supply.

Prevent skin and eye contact with liquid. Avoid inhalation of vapors. Products of thermal decomposition can form halogen acids that have very sharp, stringent effects and can be detected by odor. Such odor is a hazard warning; when detected, immediately evacuate and ventilate the area. Monitor halocarbons and oxygen levels in the work area.

Data Source(s) Code: 1, 2, 4, 7, 8, 12, 21, 26, 38, 47, 82, 84. CK

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Approvals *JO Accrocco, 6/86*

Indust. Hygiene/Safety *2/20 6/86*

Medical Review *[Signature]*

APPENDIX D. SELECTED LIST OF SUPPLIERS OF CLEAN ROOM WIPERS

1. Berkshire Corporation, River Dr., Great Barrington, MA 01230.
(413) 528-2602 (factory).
2. Coventry Mfg. Co., Inc., 5152 Commerce Drive, Baldwin Park, CA 91706
(818) 960-4981 (dealer and laundry for Milliken products).
3. Critical Environment Wipes, Div. of IFC Nonwovens, P.O. Box 1561,
Jackson, TN 38302-1561, 1-800-432-9473 (factory).
4. Milliken & Company, MDC, Industrial Fabricating, P.O. Box 2956, LaGrange,
GA 30241, (404) 883-5878 (factory and laundry), (trade name Anticon).
5. Prudential Overall Supply, 6948 Bandini Blvd., Commerce, CA 90040
(213) 722-0636 (dealer and laundry for cleanroom supplies).
6. Texwipes/ICP, Alameda Chemical & Scientific Inc., 1339 Lawrence Dr.,
Newbury Park, CA 91320, (805) 498-4555 (dealer for factory laundered
wipers).
7. Thomas E. West Co., Inc., P.O. Box 592, 1510 Notre Dame Ave., Belmont, CA
94002, (415) 592-0806 (dealer for Milliken and other products).

LABORATORY OPERATIONS

The Aerospace Corporation functions as an "architect-engineer" for national security projects, specializing in advanced military space systems. Providing research support, the corporation's Laboratory Operations conducts experimental and theoretical investigations that focus on the application of scientific and technical advances to such systems. Vital to the success of these investigations is the technical staff's wide-ranging expertise and its ability to stay current with new developments. This expertise is enhanced by a research program aimed at dealing with the many problems associated with rapidly evolving space systems. Contributing their capabilities to the research effort are these individual laboratories:

Aerophysics Laboratory: Launch vehicle and reentry fluid mechanics, heat transfer and flight dynamics; chemical and electric propulsion, propellant chemistry, chemical dynamics, environmental chemistry, trace detection; spacecraft structural mechanics, contamination, thermal and structural control; high temperature thermomechanics, gas kinetics and radiation; cw and pulsed chemical and excimer laser development including chemical kinetics, spectroscopy, optical resonators, beam control, atmospheric propagation, laser effects and countermeasures.

Chemistry and Physics Laboratory: Atmospheric chemical reactions, atmospheric optics, light scattering, state-specific chemical reactions and radiative signatures of missile plumes, sensor out-of-field-of-view rejection, applied laser spectroscopy, laser chemistry, laser optoelectronics, solar cell physics, battery electrochemistry, space vacuum and radiation effects on materials, lubrication and surface phenomena, thermionic emission, photo-sensitive materials and detectors, atomic frequency standards, and environmental chemistry.

Computer Science Laboratory: Program verification, program translation, performance-sensitive system design, distributed architectures for spaceborne computers, fault-tolerant computer systems, artificial intelligence, micro-electronics applications, communication protocols, and computer security.

Electronics Research Laboratory: Microelectronics, solid-state device physics, compound semiconductors, radiation hardening; electro-optics, quantum electronics, solid-state lasers, optical propagation and communications; microwave semiconductor devices, microwave/millimeter wave measurements, diagnostics and radiometry, microwave/millimeter wave thermionic devices; atomic time and frequency standards; antennas, rf systems, electromagnetic propagation phenomena, space communication systems.

Materials Sciences Laboratory: Development of new materials: metals, alloys, ceramics, polymers and their composites, and new forms of carbon; non-destructive evaluation, component failure analysis and reliability; fracture mechanics and stress corrosion; analysis and evaluation of materials at cryogenic and elevated temperatures as well as in space and enemy-induced environments.

Space Sciences Laboratory: Magnetospheric, auroral and cosmic ray physics, wave-particle interactions, magnetospheric plasma waves; atmospheric and ionospheric physics, density and composition of the upper atmosphere, remote sensing using atmospheric radiation; solar physics, infrared astronomy, infrared signature analysis; effects of solar activity, magnetic storms and nuclear explosions on the earth's atmosphere, ionosphere and magnetosphere; effects of electromagnetic and particulate radiations on space systems; space instrumentation.